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Original Article

AN EXPERIMENTAL ANALYSIS AND PROCESS PARAMETER OPTIMIZATION ON FRICTION STIR WELDED DISSIMILAR ALLOYS

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ABSTRACT

The aim of this exertion is to examine on the tensile strength of dissimilar aluminium sheets are (AA6063 and AA5052) joined by FSW. The two aluminium sheets are arranged in a line with perpendicular rolling directions of the tool. The sheets are successfully welded and the welded sheets are tested under tension at room temperature in order to examine the strength. The two aluminium sheets are arranged in a line with perpendicular rolling directions of the tool. The Taguchi L9 experimental technique is picked to build the quantities of welding tests. The ideal range of process parameters and their possessions upon the tensile strength of the weld joints is analysed by ANOVA. The sheets are successfully welded and the welded sheets are tested under tension and hardness at room temperature in order to examine the strength. The result shows that the welding speed is 800rpm, feed is 30 mm / min and tilt angle 1.5 are the influential process parameters to join these dissimilar joints.

KEYWORDS: Dissimilar Alloys, Welding Speed, Feed, Tilt Angle, Taguchi Approach & ANOVA Analysis

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INTRODUCTION

AA 6063 is an age intense empower aluminium compound and AA 5052 is a strain extreme capable aluminium amalgam and yet both combinations show higher explicit quality, unrivalled malleability, and higher erosion obstruction [1-3]. The disparate welding of these two metal sheets prompts the joint properties of both parent metals, which makes this amalgamation particularly required in numerous applications, for example, marine, airship, engineering, all-purpose sheet metal work, heat exchangers, fuel tanks and lines, and so forth. Combinations welding like gas tungsten arc welding and gas metal arc welding process are commonly used to couple these composites. In light of the variety in compound arrangement, softening point, warm development coefficient and other dynamic mechanical properties the combination welding of disparate metal sheets is a greater challenge [4]. The nature of the weld is deteriorating since the issues related to solidification, for example, porosity, hot breaking, and so forth. The poor dynamic mechanical properties account the improvement of coarse grains and high between metallic groups in the welding territory. The fusing arc to connect the dissimilar compounds is constraining the development of thick unshakable ceramic oxide layer on the outside of the parent metals. This oxide layer arrangement is the significant confinement of combination welding procedures to weld the aluminium compounds.FSW grants the different metals to be coupled well beneath the softening point temperature

of the parent metals. The advancement of weak solicited yield can be limited and because of the location breaking of grain limit will be evacuated. In light of metal flow practices, the improvement of imperfection free contact blend welded locale [5-6]. The substance composition of AA 6063 and AA 5052 is recorded in Table 1 and Table 2.

Table 1: Chemical Synthesis of 6063

Components	Al	Mg	Cr	Cu	Fe	Ti	Mn	Zn	Si
Wt.%	97.65	0.45-0.9	0-0.1	0.1	0.35	0-0.1	0.1	0-0.1	0.2-0.6

Table 2: Chemical Composition of 5052

Components	Al	Mg	Cr	Cu	Fe	Zn	Si	Others
Wt.%	98.45	0.1	0.15-0.35	0.1	0.4	0.1	0.25	0.15

FSW is a solid state, hot-cut off amalgamation method [7– 9] in which a pivoting device with a shoulder and terminated in an tool stick, moves along the butting appearances of two unbendingly fixed metal sheets situated on a support plate as appeared in Figure 1. The shoulder reaches the best essence of the parent metal. Warmth is created by contact at the shoulder and to a base sum at the stick face, mellows the metal is to be welded. High plastic deformation and plasticized material stream occurs as the apparatus is deciphered along the welding bearing. The parent metal is transported from the front device to the trailing edge of material where it is manufacturing into a joint. In spite of the fact that Figure 1 demonstrates a butt joint for outline, lap joints, fillet joints and different sorts of joints can likewise be created by FSW. The course of turn in any one half of the sheets or the instrument is the equivalent in the stream of welding is called as propelling side, with the opposite side picked as withdrawing side. This refinement may manual for asymmetry in warmth exchange, stream of material and the mechanical properties of the welded specimen [10], For instance, the hardness of divergent aluminium combinations shelter be lesser in the Heat affected area on the withdrawing side, which it turns into the area of pliable disappointment in the tensile investigation [11].

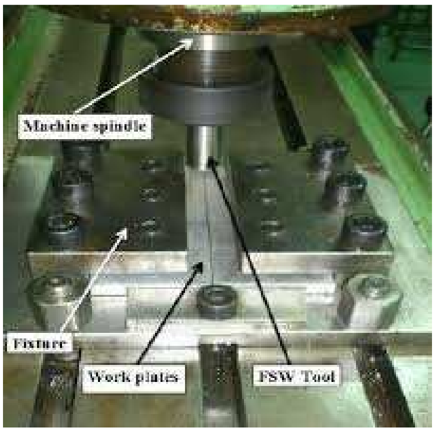

Figure 1: Friction Stir Welding Process

Geometry of the tools and parameters of the welding process is playing the important role in deciding the weld quality in FSW process. The process parameters such as welding speed, Feed, tilt angle and axial tool pressure, etc., play a major role in deciding the weld quality. The influence of some of the important parameters such as welding speed, Feed, tilt angle on weld properties have been investigated. Therefore, an attempt was made in this investigation to understand the effect of tensile strength properties of friction stir welded joints from process parameters. The L9 orthogonal array is utilized to recognize the various process parameters and the ANOVA analysing method approach is employed to examine the obtained results. Taguchi approach is used for finding optimal process parameter combinations to attain maximum

tensile strength. This technique is employed to find preferred quality based on the design of experiments [12]. System design and parametric design are achieved effectively using this method. Optimization of any problem can be easily solved by the Taguchi based design of experiments [13].

EXPERIMENTAL PROCEDURE

The AA6063 and AA5052 disseminate alloys are chosen for the investigations. The metals are to be joined sheets are clearly polished by grinding wheels and then all burrs are removed from the surface of the materials using emery papers. The two sheets are properly fixed in fixtures and joined by the FSW. Two important parameters of friction stir welding process are the geometry of the tool, joining parameters and weldment design of the joint. Based on the parent sheet thickness, the tool pin diameter is selected and is must be equal. The joining method parameters are welding speed (in rpm) in dextral or counterclockwise direction, tool traverse speed or feed (in mm/min) on the road of joint and angle of spindle or tool angle with regard to the surface of the welding specimens. The friction stir welding arrangements is shown below in the figure 1. The materials are joined using welding tool and there are different types of tool geometry profile are used. The tool profiles are rectangular, square, hexagonal, threaded, etc., and the is made of a hardened carbon steel. The Taguchi L9 experimental technique is picked to build the quantities of welding assessments. The precise range of system parameters and their possessions upon the tensile power of the weld joints is analysed with the aid of ANOVA. Larger is better is chosen to acquire the most tensile strength in Taguchi technique. The operating ranges of process parameters are selected as follows; the rotational speed is 520, 600, 800 rpm, feed is 20, 30, 30 mm/min and tilt angle is 1.5, 2 and 2.5. The L9 Taguchi method is correctly used for the layout and analysis of the experiment. Based on the L9 array approach, the parameters are selected to join nine specimens. The welded specimens are cut for tensile test using Electron Discharge Machine (EDM) followed American Standard Testing Material (ASME). Table 3 shows the different set of process parameters for joining the dissimilar alloys.

Tensile Test

Tensile testing, also called as tension examine, is an essential test to find the mechanical properties in which a sample is subjected to a managed tension until failure. Properties which can be without delay measured via a tensile check are closing tensile strength, breaking strength, most elongation of welded pieces and reduction in area of samples. From those measurements the following characteristics can also be indomitable. The modulus of elasticity, Poisson's ratio, yield strength of specimen and pressure hardening characteristics. Uniaxial tensile checking out is the maximum usually used for acquiring the mechanical characteristics of isotropic substances. A few materials use biaxial tensile checking out. The Tensile test of material was tested by TUE-C-200(SERVO) type computerized universal testing machine which was shown in Figure 2. A traction sample is a standardized cross - section of the sample. Section of the sample. There are two shoulders and a gauge (section). The shoulders are large so that they can be easily grasped, while the section of the gauge has a smaller cross section so that buckle or deformation and fracture can occur in this smaller area. The schematic diagram of a tensile test specimen was shown in Figure 3. The test result of the nine specimens is mentioned in Table 4.

Table 3: Range of Process Parameters

S. No	Welding Speed (rpm)	Feed (mm/min)	Tilt Angle (mm/min)
1	800	40	2
2	800	30	1.5
3	520	30	2

Table 3: Contd.,			
4	600	40	1.5
5	800	20	2.5
6	600	20	2
7	520	40	2.5
8	520	20	1.5
9	600	30	2.5

Figure 2: Universal Testing Machine

RESULTS AND DISCUSSIONS

The response tensile strength of the welded specimen is observed for each experiment and recorded in the Table 4.

Table 4: Result of Tensile Strength

S. No	Welding Speed (rpm)	Feed (mm/min)	Tilt Angle (mm/min)	Tensile Strength (MPa)
1	800	40	2	131.78
2	800	30	1.5	127.08
3	520	30	2	101.85
4	600	40	1.5	107.86
5	800	20	2.5	100.49
6	600	20	2	113.76
7	520	40	2.5	110.56
8	520	20	1.5	114.29
9	600	30	2.5	116.31

Taguchi Parametric Optimization

Taguchi approach is used for finding optimal process parameter combinations to attain maximum tensile strength. This technique is employed to find preferred quality based on the design of experiments [13]. System design and parametric design are achieved effectively using this method. Optimization of any problem can be easily solved by Taguchi based design of experiments [14, 15].

ANOVA Table Analysis for Tensile Strength

The experiments are carried out on the basis of an orthogonal array that reduces the variety of experiments. All experimental outcomes have become a signal-to-noise ratio. The variations of the performance individuality from the desired values have been measured by this ratio efficiently. The performance of the responses are mainly depends upon the

S/N ratio whether it may be the maximum and minimum [15]. In this experiment, higher amount of material removal rate and minimum surface roughness have been considered. Mean of S/N ratio and ANOVA table are shown in the Table 5 and Table 6. In the Table 5, the delta value is high for welding speed. It means that the welding speed shows more impact on tensile strength. From the Table 6, the P value is 0.085, it shows that the welding speed is more impact than feed and tilt angle in tensile strength.

Table 5: ANOVA Analysis Result for Tensile Strength

Level	Speed of Welding ((rpm)	Feed (mm/min)	Tilt Angle (mm/min)
1	100.98	113.24	101.33
2	110.87	102.42	113.06
3	114.78	112.96	112.69
Delta	3.857	1.623	1.66
Rank	1	2	3

Table 6: ANOVA Analysis for Welding Speed, Feed and Tilt Angle

Source	DF	Adj. SS	Adj. MS	F-value	P-Value
Welding Speed	2	22.9	11.3	10.72	0.085
Feed	2	5.03	2.51	2.39	0.30
Tilt angle	2	4.78	2.39	2.27	0.31
Error	2	2.11	1.05		
Total	**8**	**34.52**			

S=3.024, R-sq=83.9 %, R-sq (adj)=85.7 %

Contour Plot Analysis for Tensile Strength

Contour plot is used find the impact of two different process parameters on the responses. The contour plot analysis for welding speed versus feed is given in Figure 3. The greater amount of tensile strength is reached at higher value of welding speed and feed.

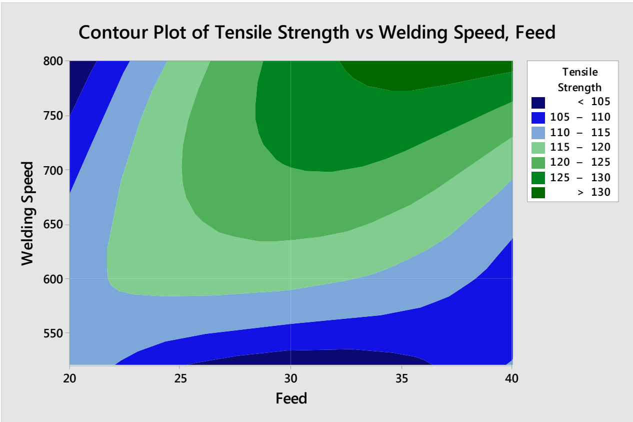

Figure 3: Tensile Strength vs Welding Speed, Feed

The contour plot analysis for welding speed versus tilt angle is given in Figure 4. The greater amount of tensile strength is reached at higher value of welding speed and medium value of tilt angle.

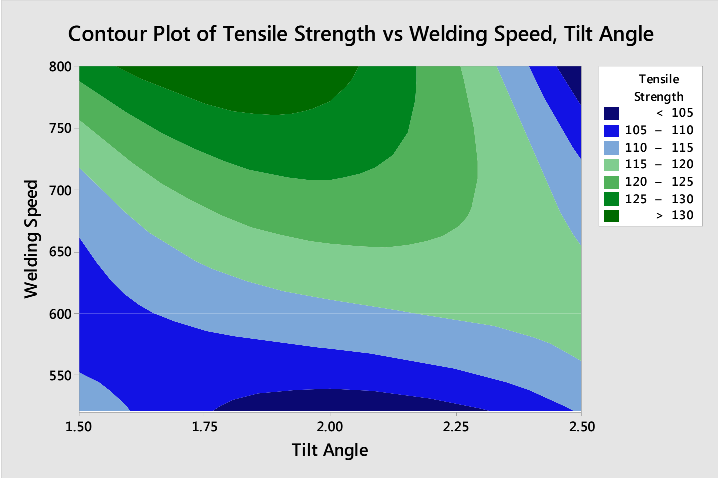

Figure 4: Tensile Strength vs Welding Speed, Tilt Angle

The contour plot analysis for feed versus tilt angle is given in Figure 5. The greater amount of tensile strength is reached at a medium value of feed and low value of tilt angle and high value of feed and medium value of tilt angle. of welding speed and feed.

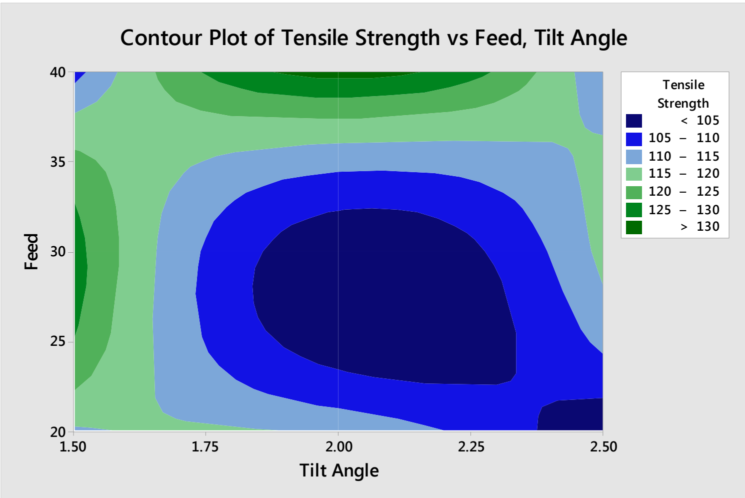

Figure 5: Tensile Strength vs Feed, Tilt Angle

CONCLUSIONS

In this research, the two dissimilar aluminium alloys are joined by FSW. The experimental method Taguchi L9 orthogonal is applied to develop the number of welding experiments. Based on ASME standard tensile test specimen is extracted using the wire cut EDM. The sheets are successfully welded and the welded sheets are tested under tension using a universal testing machine at room temperature in order to examine the strength. ANOVA experimentation, analysis is carried out in order to obtain the most suitable (optimum) range of selected parameters and their results on the tensile strength weld joints. The result shows that the welding speed is 800rpm, feed is 30 mm / min and tilt angle 1.5 are the influential process parameters to join these dissimilar joints.

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